

ENHANCING MERCURY CONTROL ON COAL-FIRED BOILERS WITH SCR, OXIDATION CATALYST, AND FGD

Mercury capture in existing emissions control equipment offers a cost effective mercury control option for coal-fired power plants. The incidental capture of mercury from coal-fired power plants varies significantly depending on the existing emissions control configuration and type of coal being burned. Different coals and control configurations produce varying amounts of the three basic forms of mercury in flue gas including elemental, oxidized, and particulate mercury. Particulate mercury will typically be captured in the particulate control device and oxidized mercury is water soluble and can therefore be captured in certain control equipment such as wet flue gas desulfurization (FGD) systems.

In order to enhance mercury capture, the elemental form of mercury can be catalytically oxidized from the elemental metallic form, Hg^0 , to the oxidized form of mercury, Hg^{+2} , and captured by a downstream FGD system. Selective catalytic reduction (SCR) catalysts or oxidation catalysts may be used for the catalytic oxidation step, followed by downstream wet or dry FGD technology to capture the oxidized mercury. High levels of oxidized mercury and total mercury capture are achieved commercially when firing bituminous coal. Enhancement of mercury capture efficiency for low-halogen coals (i.e. coals with low chloride content such as subbituminous or lignite coals) can be done by either the addition of halogen-containing compounds to the boiler or by co-firing higher-halogen content coals. Co-firing involves blending in 15 to 50 percent bituminous coal when firing low-halogen subbituminous or lignite coal types. Liquid reagents may also be added to the FGD system to prevent the reemission of oxidized mercury in the flue gas.

Technology Overview

Flue gas desulfurization is a widely used post-combustion technology for controlling SO_2 emissions. FGD also captures a large percentage of oxidized mercury present in coal-fired combustion flue gas because the oxidized mercury is soluble in the calcium-containing liquid solution in the FGD. However, FGD does not effectively capture elemental mercury from the flue gas because elemental mercury is not soluble in the liquid solution. For bituminous firing, there is a medium to high level of oxidized mercury at the FGD inlet resulting in a comparable level of mercury capture. For sub-bituminous and lignite firing, the relative levels of oxidized mercury and subsequent capture are both low. Neither “wet” FGD nor “dry” FGD is effective in capturing elemental mercury. In a dry FGD unit, also known as spray dryer adsorber (SDA), a calcium-containing liquid solution is sprayed into the flue gas to capture SO_2 but does not saturate the flue gas like wet FGD. For dry FGD, the subsequent baghouse normally provides additional contact time thus effectively allowing the combined SDA/baghouse configuration to capture oxidized mercury as efficiently as wet FGD units.

Selective catalytic reduction (SCR) is a widely-employed post-combustion method for controlling NO_x emissions. Although SCR catalyst reduces NO_x, it also has the dual-function of oxidizing mercury. This can be a significant co-benefit as SCR installed upstream of an FGD will result in a higher overall mercury capture. A good number of plants are expected to be operating with SCR/FGD control combinations due to the requirements of EPA's Clean Air Interstate Rule that requires significant SO₂ and NO_x reductions from power plants. For bituminous firing, 80 percent to over 95 percent overall mercury capture has been observed in full-scale plant tests where SCR followed by wet FGD is employed. A large bituminous-fired plant equipped with SCR and wet FGD showed sustained high Hg capture performance over multiple ozone operating seasons. Firing of low chlorine containing subbituminous and lignite coals will require process enhancements, such as those outlined below, in order to achieve high mercury capture.

Oxidation catalysts containing precious metals are being commercially demonstrated for the oxidation of mercury. These catalysts can be installed upstream of an FGD and perform in a similar manner to SCR catalyst. Oxidation catalyst can be installed between the SCR catalyst and the FGD to enhance the overall performance of the SCR system for mercury oxidation. Greater than 90 percent mercury oxidation efficiency has been achieved firing PRB (subbituminous) and North Dakota lignite coals in slipstream tests at power plants.

Process Augmentation for Mercury Capture Enhancement

The following options to increase the efficiency of mercury capture of the SCR/FGD or Oxidation Catalyst/FGD process are in various stages of development and/or field demonstration:

- (a) Addition of chlorine, bromine or other halogens to the coal (pre-combustion), directly to the boiler (combustion), or after the boiler (post-combustion). The halogens combine with the oxidized mercury to form mercury halides to improve mercury capture. This approach is especially useful when firing low halide containing coals.
- (b) Blending of subbituminous or lignite coals with the addition of bituminous coal. This technique can be used to improve overall mercury capture for FGD, SCR/FGD and Oxidation Catalyst/FGD configurations. Performance tests at a large utility plant firing a 60 percent Subbituminous and 40 percent bituminous blend at two identical boilers (one equipped with SCR and the other without SCR) showed an increase in downstream oxidized mercury fraction from 63 percent without SCR to 97 percent with SCR. The unblended PRB sub-bituminous coal would have only achieved between 0-40 percent oxidized mercury.
- (c) Addition of catalysts to specifically convert elemental mercury to oxidized mercury. This can include addition of an extra SCR catalyst layer, a mercury-specific oxidation catalyst added after (or in lieu of) the SCR catalyst layers in a hot flue gas location, or the addition of a mercury-specific oxidation catalyst in a relatively cool flue gas location. For subbituminous and lignite firing, the hot-side catalysts may require augmentation of

flue gas chlorine to be effective whereas the cold-side catalysts are effective without chlorine augmentation.

- (d) Addition of FGD additives to avoid re-emission of captured mercury is another technique. Commercial tests have shown 0-15 percent re-emission of captured mercury from wet FGD units, and additives have shown the ability to substantially prevent this re-emission effect.

Performance

The overall mercury capture efficiency depends on the configuration of post-combustion air pollution control equipment and coal type at a particular plant. EPA has developed the following estimates of incidental mercury capture efficiencies for some of the major plant configurations involving FGD or combined SCR/FGD (those shown are for pulverized coal fired boilers). These incidental efficiencies are not optimized for mercury capture and may be optimized further.

Post-Combustion Controls			Mercury Capture Efficiency		
<i>PM</i>	<i>NO_x</i>	<i>SO₂</i>	<i>Bituminous</i>	<i>Subbituminous</i>	<i>Lignite</i>
ESP	None	Wet FGD	66%	16%	44%
ESP	None	Dry FGD	36%	35%	0%
ESP	SCR	Wet FGD	90%	66%	44%
ESP	SCR	Dry FGD	36%	35%	0%
None	None	Wet FGD	42%	30%	0%
None	None	Dry FGD	40%	15%	0%
None	SCR	Wet FGD	90%	51%	0%
None	SCR	Dry FGD	40%	15%	0%

Note: ESP is cold-side electrostatic precipitator.

Actual performance is somewhat variable. As an example, a 550 MW bituminous-fired unit equipped with ESP, SCR and wet FGD resulted in greater than 90 percent overall mercury capture in the downstream wet FGD unit. With the usage of the SCR catalyst, the oxidized fraction of mercury in the flue gas increased from 64 percent of total gaseous mercury to over 95 percent.

Typical Costs

Site-specific factors result in significant variation in costs. Costs for augmentation technologies are generally expected to be low to moderate in terms of capital investment and low to moderate in operating costs.

Installation and Availability

Around one-third of the coal-fired capacity in the U.S. has installed FGD for SO₂ control and SCR for NO_x control. The majority of the FGD installations are wet FGD systems. A

significant number of existing coal-fired power plants are currently retrofitting or planning on retrofitting their boilers with FGD and/or SCR systems, which are more suited for the low cost mercury control options previously discussed. The enhanced control approaches primarily utilize reagents and catalysts that are readily available in adequate quantities for initial operation and continued operation of these control systems. The augmentation technologies being commercialized are expected to become readily available and not limited by installation manpower, equipment, or consumables.